T. PULLAIAH* & D. NARAHARA*: **Embryology of *Amaranthus spinosus* L.**

T. プライア*・D. ナラハラ*: ハリビユの胚学的研究

Embryological investigations in the family Amaranthaceae are few and these have been reviewed by Savina (1983). Although the genus *Amaranthus* consists of 60 species, embryology of only 6 species—*A. blitum* (Dahlgren 1916), *A. caudatus, A. retroflexus* (Souèges 1937a, b), *A. viridis* (Kajale 1940), *A. leucocarpus* (Sebastian & Deshpande 1974), and *A. mangostanus* (Narahara & Pullaiah 1986)—has been investigated. Hence the present investigation is undertaken and the present report deals with the embryology of *Amaranthus spinosus* L. Mendoza (1973) studied the post-globular stages of embryo development but she has not studied the earlier stages of embryo development and did not assigned the development of embryo to any type.

Material and methods Buds, flowers and fruits were collected from the plants growing in the fields near the University and fixed in formalin-acetic-alcohol (F.A.A.). Dehydration was carried in tertiary butyl alchol series. Embedding was done in paraffin wax of 58-60°C. Serial longi- and transections were cut at a thickness of 4-6 μm and stained in Delafield's haematoxylin. The voucher specimen TP & DN 1265 has been deposited in the Herbarium of Sri Krishnadevaraya University and Madras Herbarium, Coimbatore.

Observations Microsporangium, microsporogenesis and male gametophyte. The anthers are quadrisporangiate (Fig. 1, A). The male archesporium is 5-7-celled in longitudinal section (Fig. 1, B) and 2-3-celled in transverse section. The anther wall develops according to the Monocotyledonous type of Davis (1966) (Fig. 1, B-E). The hypodermal layer develops as fibrous endothecium (Fig. 1, M, N). The middle layer becomes distorted and crushed. The tapetum is of the secretary type (Fig. 1, E) and their cells remain uninucleate. Minute oily globules known as orbicules or ubisch bodies appear on the inner side of the tapetum during pollen grain development. The tapetum is consumed by the developing pollen grains and no trace of it is left at maturity.

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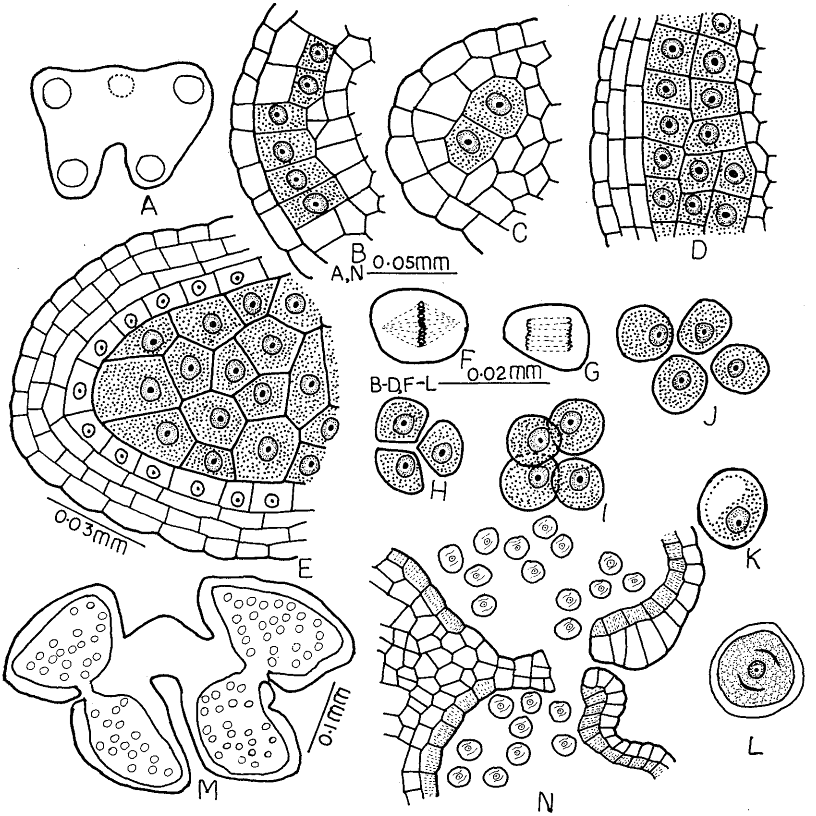

Fig. 1. *Amaranthus spinosus*. A. Transverse section of tetrasporangiate anther. B. Longitudinal section of part of anther lobe showing archesporium of which two cells have already divided. C. Transverse section of anther lobe showing sporogenous cells and parietal layer. D. Longitudinal section of part of anther lobe showing sporogenous cells and two parietal layers. E. Transverse section of anther lobe showing pollen mother cells and wall layers. F, G. Pollen mother cells in meiosis. H-J. Pollen tetrads. K. One-nucleate pollen grain. L. 3-celled pollen grain. M. Transverse section of mature anther. N. Portion enlarged from figure M.

The pollen mother cells in each sporangium are a moderate mass of cells (Fig. 1, E). The pollen mother cells undergo meiosis resulting in tetrahedral, isobilateral and decussate (Fig. 1, F-J) pollen tetrads. Cytokinesis is simultaneous. Microspore after its release enlarges (Fig. 1, K). The pollen grains at the time of shedding are 3-celled with thick exine (Fig. 1, L).

Ovule, megasporogenesis and female gametophyte. The ovule which arises

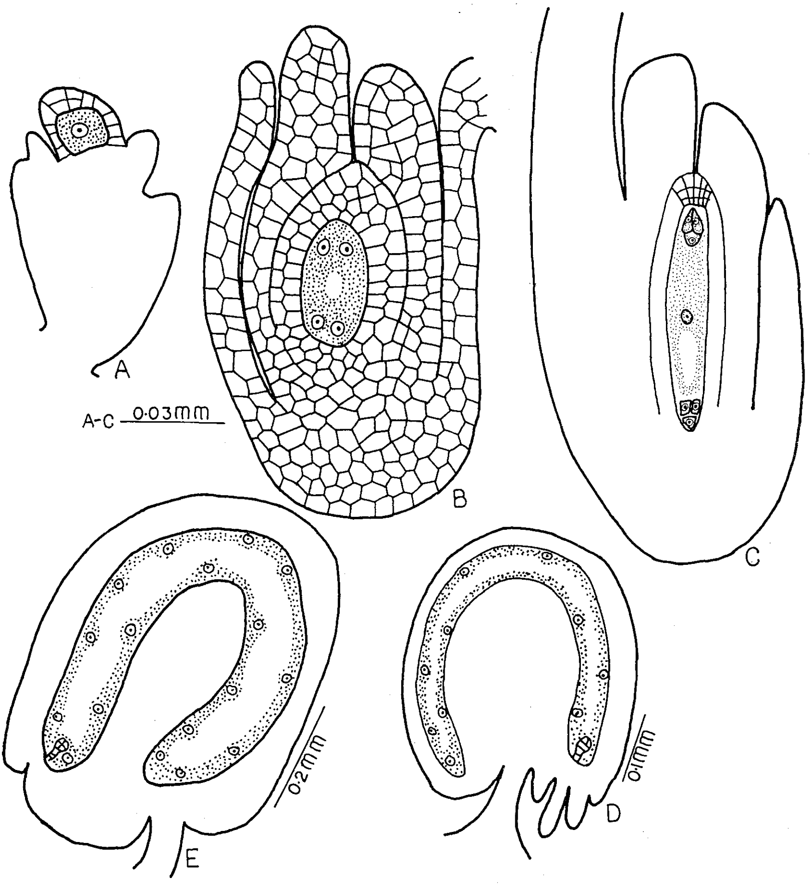

Fig. 2. *Amarathus spirosus.* A-E. Stages in the development of ovule.

as a papillate outgrowth becomes curved and anatropous (Fig. 2, A-C). Due to further curvature the ovule becomes amphitropous (Fig. 2, D, E). The ovule is bitegmic and crassinucellate. The micropyle is formed by the inner integument. Both the integuments are two-layered but the inner is more massive at the micropylar end where it is 4-layered.

Female archesporium is 1-celled. It cuts off a parietal cell towards the micropyle which after periclinal and anticlinal divisions forms a massive parietal tissue. Megaspore mother cell undergoes meiosis followed by cytokinesis.

Usually the micropyal dyad cell fails to undergo division and consequently a linear triad is formed (Fig. 3, A). The chalazal megaspore is functional while the remaining megaspores degenerate. . The functional megaspore undergoes three mitotic divisions resulting in an 8-nucleate, 7-celled embryo sac of the

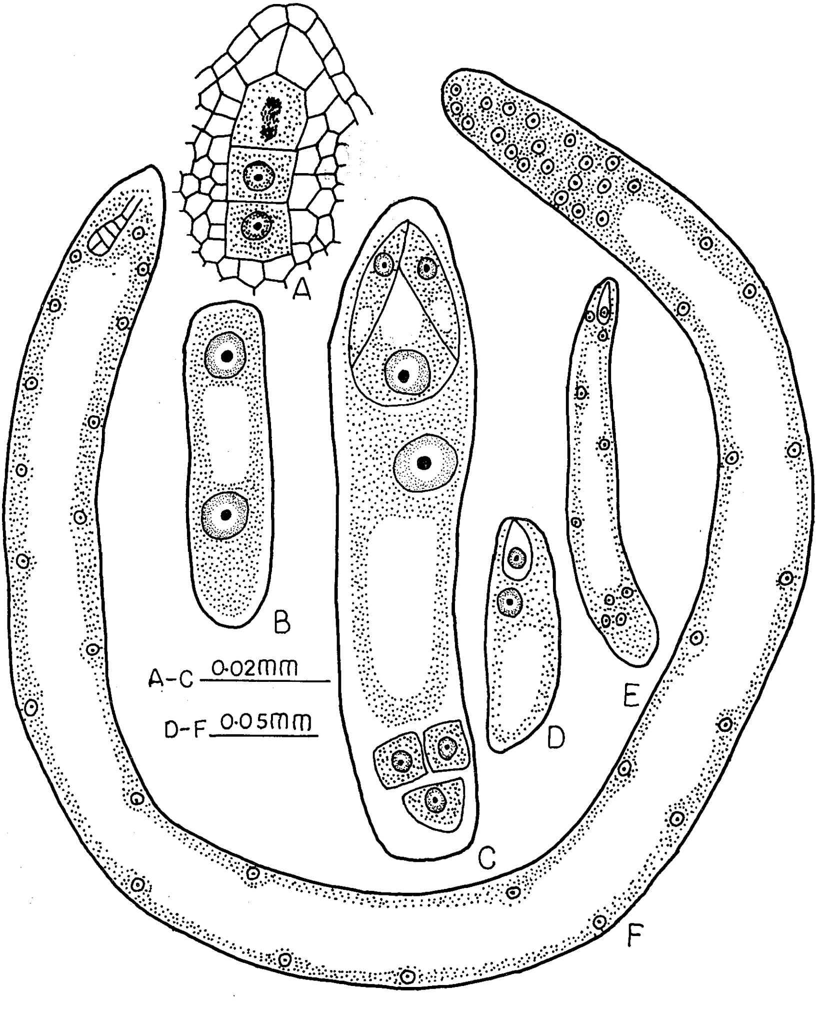

Fig. 3. *Amaranthus spinosus.* A. Megaspore triad. B, C. Two-nucleate and organised embryo sacs respectively. D-F. Stages in the development of endosperm.

Polygonum type (Fig. 3, B, C). The synergids have no hooks. The polar nuclei fuse prior to fertilisation. Antipodal cells are three in number and they are ephemeral.

Fertilisation, endosperm and embryo. Fertilisation is porogamous. Endosperm development is of the nuclear type. The primary endosperm nucleus divides long before zygote formation (Fig. 3, D, E). These nuclei undergo further divisions and the nuclei are distributed in the periphery while the centre is occupied by a large vacuole (Fig. 3, E, F). A large number of nuclei are aggregated in the chalazal region (Figs. 3, F). Cellularisation starts at the time of cotyledon initiation and it proceeds from the micropylar end towards the chalazal end. The endosperm becomes cellular completely. The growing embryo consumes most of the endosperm leaving one or two layers in the mature seed.

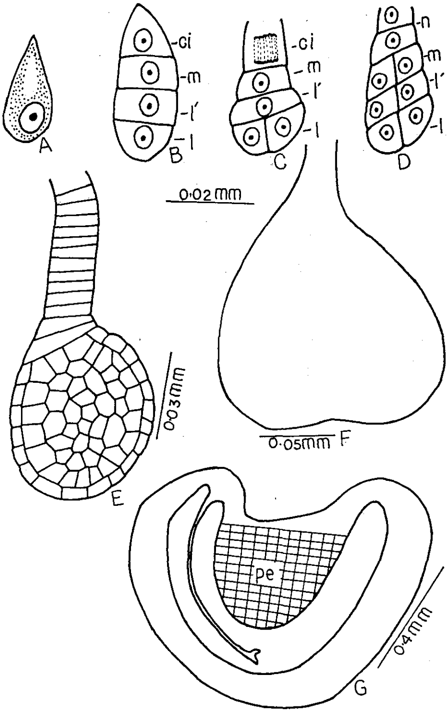

Fig. 4. *Amaranthus spinosus.* A. Zygote. B–E. Stages in the development of embryo. G. Longitudinal section of ovule showing curved embryo and perisperm. (pe, perisperm).

The zygote (Fig. 4 A) undergoes two transverse divisions resulting in a linear 4-celled proembryo (Fig. 4B). The tiers from the tip are designated as *l*, *l′*, *m* and *ci*. The tiers *l*, *l′* and *m* undergo two vertical divisions at right angles to one another while the cell *ci* divides transversely forming *n* and *n′*. (Fig. 4, C, D). During further development the tier *l* gives rise to stem tip and cotyledons, *l′* and *m* to the hypocotyl and part of *ci* to the root tip and root cap (Fig. 4, E, F). The remaining part of *ci* forms suspensor of 12–14 cells. Thus the embryo development conforms to the chenopodiad type. The mature embryo is curved (Fig. 4, G).

Perisperm. The elongated

and curved embryo encloses the central part of the nucellus which persists in the mature seed (Fig. 4 G). This tissue is known as the perisperm.

Discussion The taxon studied fits in well with the picture obtained from previous studies on the embryology of other representatives of the family except the ovular curvature. The ovule has been described as campylotropous, anacampylotropous and amphitropous by different embryologists. The ovule in the present investigation was found to be amphitropous and in the opinion of the authors the ovule in other members of Amaranthaceae should also be designated as amphitropous.

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ハリビユの胚学的研究を行った。花粉壁のできかたは単子葉型である。タペタムは分泌状型。花粉は3細胞期に放出される。胚嚢形成はタデ型。胚乳形成は多核型。胚形成はアカザ型である。これは今までのヒユ属のものと一致する。ただ今まで胚珠は campylotropous, anacampylotropous とか amphitropous などといわれてきたが，amphitropous とすべきである。